MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 1, 2016/2017

ETM3136 – DIGITAL COMMUNICATIONS

(TE)

07 OCTOBER 2016
09:00 a.m – 11:00 a.m
(2 Hours)

INSTRUCTION TO STUDENTS

1. This question paper consists of 7 pages with 4 Questions only.
2. Attempt **ALL FOUR** questions. All questions carry equal marks and the distribution of the marks for each question is given.
3. Please write all your answers in the Answer Booklet provided.

Question 1

First time in your job as a telecommunication engineer, you got a mission to design a system for FM radio stations. The FM radio channels are multiplexed using time-division multiplexing (TDM) and transmitted through an optical fiber network. The optical fiber has bandwidth 26.32MHz. The disc jockey (DJ) control the music and each audio signal (sinewave) is a baseband signal with bandwidth 5 KHz and 0.5v peak to peak amplitude. The transmission should be in digital form, and each digital signal has a bandwidth 1MHz, and to avoid any intersymbol interference, you have to use raised-cosine pulse with a 90% roll-off factor. Since the transmit signals are digital, the encoder of analog-to-digital converter has only 3 bits. The following parameters need to be checked before the sale:

1. What is the transmit date rate? [2 marks]
2. Considering you are using uniform quantizer, how many levels does this quantizer has? [2 marks]
3. What is the value of the quantization error? [2 marks]
4. How many channels does the optical fiber can accommodate? [2 marks]
5. What is the data rate of each signal? [2 marks]
6. What is the minimum sampling rate? [3 marks]
7. What is the real sampling rate? [3 marks]
8. How much in terms of percentage the real sampling rate above the minimum sampling rate? [3 marks]
9. What is the signal to noise ratio (SNR) of each transmit signal? [3 marks]
10. What is the signal to quantization noise ratio (SQNR)? [3 marks]

Continued...

Question 2

In a digital communication system, an analog signal $m(t)$ is digitized at sampling rate 57000 samples/s. To avoid intersymbol interference (ISI), a raised-cosine spectrum with a roll-off factor 95% is employed. The system used to send the signals over 30km through an optical fiber, so the digital signal shifted using 16PSK with a bandwidth 416.812 KHz.

1. As a telecom engineer who designed this system, how many levels does the quantizer has in the analog to digital converter component? [10 marks]

2. Let us consider you want to secure the generated digital data by using direct sequence spread spectrum, where the data spread by pseudo noise (PN) sequence, which is generated by linear feedback-shift register of length $m = 5$. A white Gaussian noise (AWGN) with a power spectral density $N_0 = 1\times 10^{-16}$ W/Hz interfered the signal. Binary PSK is used to digitally modulate the data.
   a. Find the chip rate R_c [5 marks]
   b. What is the jamming margin against a continuous tone jammer if the desired error probability is 10^{-7}? [5 marks]
   c. Consider that, the transmit signal power over the 30km optical fiber is 0.62582dBm (i.e.,-29.37dBW). What is the minimum amount of power needed at the transmitter in order to maintain a bit error probability at $P_e=10^{-7}$? Assume that, the data is transmitted along an optical fiber that attenuates the signal power by 4dB. [5 marks]

Continued...

Question 3

(a) The following signals $s_1(t)$ and $s_2(t)$ are used to carry binary data. Consider that a coherent matched filter used at the receiver side.

$$s_1(t) = 0.5\cos 2000\pi t$$

$$s_2(t) = 0.5\cos 2020\pi t$$

Where the two-sided a white Gaussian noise (AWGN) power spectral density is $N_0/2 = 0.0001$ W/Hz. Assume the symbol duration is $T = 0.01$s.

1. Find the probability of bit error. [9 marks]
2. How many error could the detector made in one day? [5 marks]

(b) A continuously operating coherent BPSK system makes errors at the average rate of 21600 errors per day. The data rate is 5000bits/s. the single-sided noise power spectral density is $N_0 = 10^{-6}$W/Hz.

1. What is the average bit error probability? [5 marks]
2. If the value of received average signal power is adjusted to 0.04905W, will this received power be adequate to maintain the error probability found in part (1)? [6 marks]

Continued...

Question 4

Melaka state government want to establish new an Erlang B cellular system that will cover the area of the state, which is 1700km^2. Due to the large percentages of the population (800000) is subscribed to a cellular system, the government expecting that each user makes 1 call every 1 hour with average call duration of 3 minutes. Therefore, the government decided the following:

(i) The total bandwidth should be 35MHz.
(ii) The full duplex channel bandwidth is 50kHz
(iii) Only hexagonal cells can be used with a radius 2.5km, and the cluster size is 7 cells.
(iv) The allowable probability of call blocking is 0.05

As a telecom engineer who owns a company and wants to win this project, you have to prepare your proposal and consider the following:

1. The total number of cells in the system [3 marks]
2. The number of channels per cell [3 marks]
3. The total number of channels in the system [3 marks]
4. Traffic intensity per cell [4 marks]
5. Maximum carried traffic for the whole system [3 marks]
6. The total number of users who can use the system [3 marks]
7. Percentage of population of the city who can subscribe to the cellular service [3 marks]
8. The theoretical maximum number of users who can be served at any time. [3 marks]

End of Page

Appendix I

Tabulated values of Q-function

The Q Function (Gaussian Distribution with $\mu = 0$ and $\sigma = 1$)

$$Q(a) = \int_a^\infty \frac{1}{\sqrt{2\pi}} e^{\frac{-x^2}{2}}\, dx \qquad Q(a) \cong \frac{1}{a\sqrt{2\pi}} e^{\frac{-a^2}{2}} \text{ for } a \geq 3$$

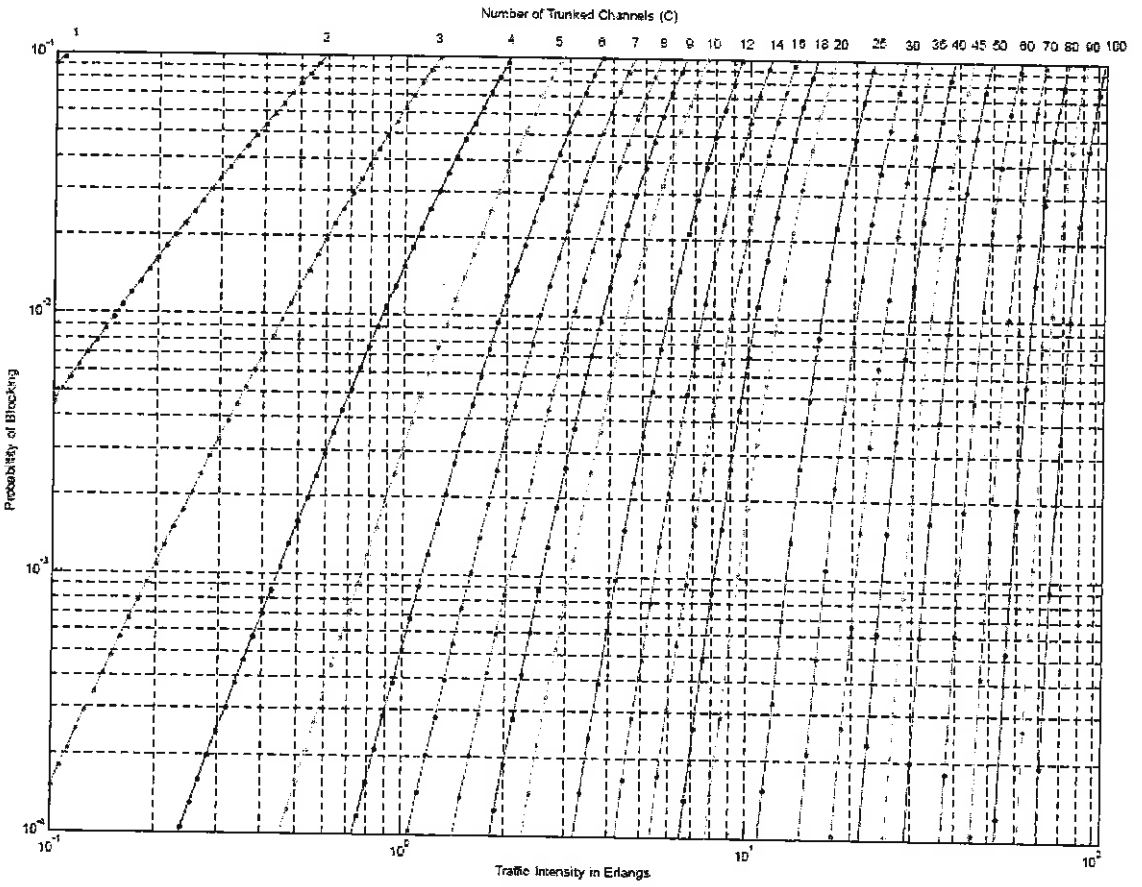
	3rd Significant Digit									
a	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	0.5000	0.4960	0.4920	0.4880	0.4840	0.4801	0.4761	0.4721	0.4681	0.4641
0.1	0.4602	0.4562	0.4522	0.4483	0.4443	0.4404	0.4364	0.4325	0.4286	0.4247
0.2	0.4207	0.4168	0.4129	0.4090	0.4052	0.4013	0.3974	0.3936	0.3897	0.3859
0.3	0.3821	0.3783	0.3745	0.3707	0.3669	0.3632	0.3594	0.3557	0.3520	0.3483
0.4	0.3446	0.3409	0.3372	0.3336	0.3300	0.3264	0.3228	0.3192	0.3156	0.3121
0.5	0.3085	0.3050	0.3015	0.2981	0.2946	0.2912	0.2877	0.2843	0.2810	0.2776
0.6	0.2743	0.2709	0.2676	0.2643	0.2611	0.2578	0.2546	0.2514	0.2483	0.2451
0.7	0.2420	0.2389	0.2358	0.2327	0.2297	0.2266	0.2236	0.2207	0.2177	0.2148
0.8	0.2119	0.2090	0.2061	0.2033	0.2005	0.1977	0.1949	0.1922	0.1894	0.1867
0.9	0.1841	0.1814	0.1788	0.1762	0.1736	0.1711	0.1685	0.1660	0.1635	0.1611
1.0	0.1587	0.1562	0.1539	0.1515	0.1492	0.1469	0.1446	0.1423	0.1401	0.1379
1.1	0.1357	0.1335	0.1314	0.1292	0.1271	0.1251	0.1230	0.1210	0.1190	0.1170
1.2	0.1151	0.1131	0.1112	0.1094	0.1075	0.1057	0.1038	0.1020	0.1003	0.0985
1.3	0.0968	0.0951	0.0934	0.0918	0.0901	0.0885	0.0869	0.0853	0.0838	0.0823
1.4	0.0808	0.0793	0.0778	0.0764	0.0749	0.0735	0.0721	0.0708	0.0694	0.0681
1.5	0.0668	0.0655	0.0643	0.0630	0.0618	0.0606	0.0594	0.0582	0.0571	0.0559
1.6	0.0548	0.0537	0.0526	0.0516	0.0505	0.0495	0.0485	0.0475	0.0465	0.0455
1.7	0.0446	0.0436	0.0427	0.0418	0.0409	0.0401	0.0392	0.0384	0.0375	0.0367
1.8	0.0359	0.0351	0.0344	0.0336	0.0329	0.0322	0.0314	0.0307	0.0301	0.0294
1.9	0.0287	0.0281	0.0274	0.0268	0.0262	0.0256	0.0250	0.0244	0.0239	0.0233
2.0	0.0228	0.0222	0.0217	0.0212	0.0207	0.0202	0.0197	0.0192	0.0188	0.0183
2.1	0.0179	0.0174	0.0170	0.0166	0.0162	0.0158	0.0154	0.0150	0.0146	0.0143
2.2	0.0139	0.0136	0.0132	0.0129	0.0125	0.0122	0.0119	0.0116	0.0113	0.0110
2.3	0.0107	0.0104	0.0102	0.0099	0.0096	0.0094	0.0091	0.0089	0.0087	0.0084
2.4	0.0082	0.0080	0.0078	0.0075	0.0073	0.0071	0.0069	0.0068	0.0066	0.0064
2.5	0.0062	0.0060	0.0059	0.0057	0.0055	0.0054	0.0052	0.0051	0.0049	0.0048
2.6	0.0047	0.0045	0.0044	0.0043	0.0041	0.0040	0.0039	0.0038	0.0037	0.0036
2.7	0.0035	0.0034	0.0033	0.0032	0.0031	0.0030	0.0029	0.0028	0.0027	0.0026
2.8	0.0026	0.0025	0.0024	0.0023	0.0023	0.0022	0.0021	0.0021	0.0020	0.0019
2.9	0.0019	0.0018	0.0018	0.0017	0.0016	0.0016	0.0015	0.0015	0.0014	0.0014
3.0	0.0014	0.0013	0.0013	0.0012	0.0012	0.0011	0.0011	0.0011	0.0010	0.0010
3.1	0.0010	0.0009	0.0009	0.0009	0.0008	0.0008	0.0008	0.0008	0.0007	0.0007
3.2	0.0007	0.0007	0.0006	0.0006	0.0006	0.0006	0.0006	0.0005	0.0005	0.0005
3.3	0.0005	0.0005	0.0005	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0003
3.4	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0002

$Q(a)$	a
10^{-4}	3.73
5×10^{-5}	3.90
10^{-5}	4.27
5×10^{-6}	4.43

$Q(a)$	a
10^{-6}	4.76
10^{-7}	5.20
10^{-8}	5.61
10^{-9}	6.00

Appendix II

Probability of Call Blocking in an Erlang B System


Number of Trunked Channels (C)
1 2 3 4 5 6 7 8 9 10 12 14 16 18 20 25 30 35 40 45 50 60 70 80 90 100
Probability of Blocking
Traffic Intensity in Erlangs

Hexagonal Cell Area = $2.598\ R^2$

Where R is the radius of the cell